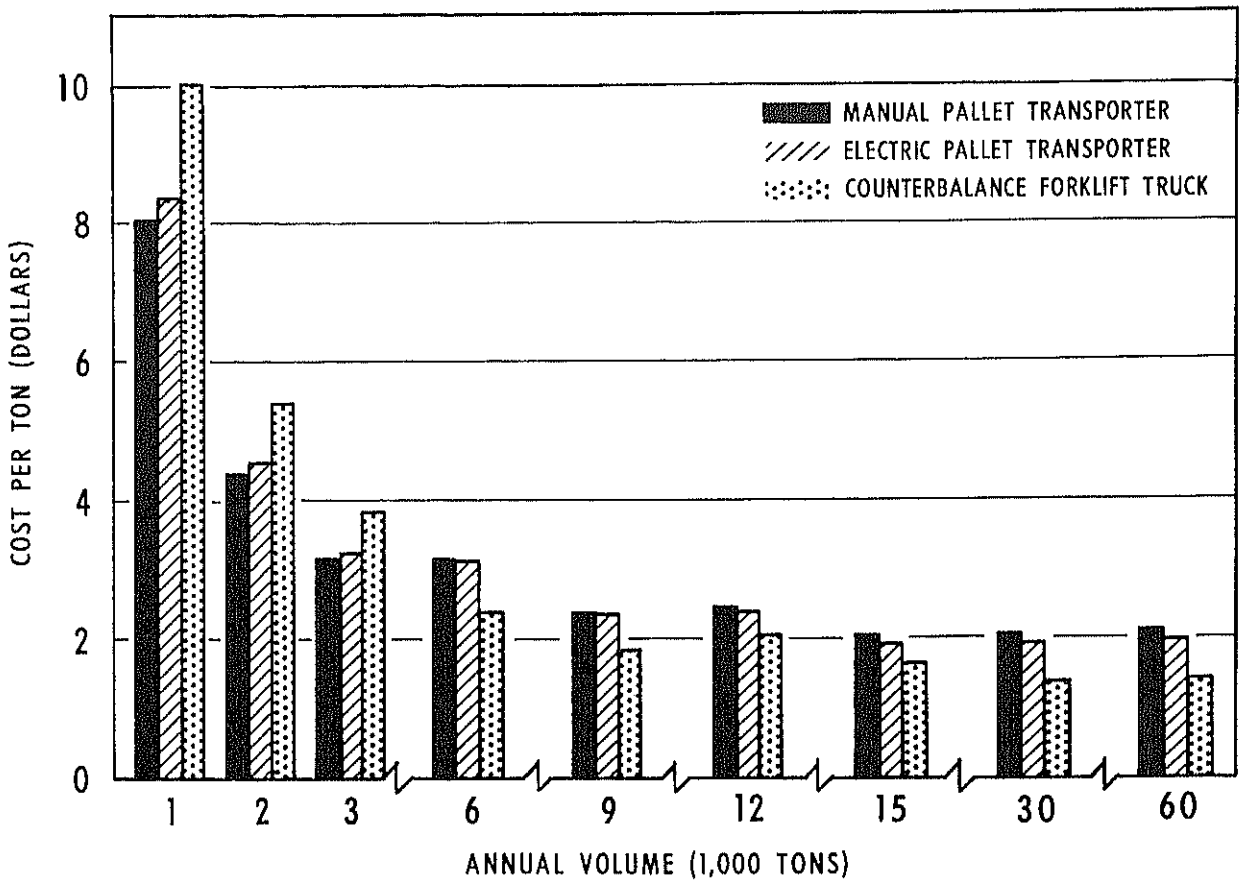

Figure 9.—Annual volume in 1,000 tons handling cost per ton, dairy and egg wholesaler.

LITERATURE CITED

(1) ALLEGRI, T. H., and HERRICK, J. F., JR.
1957. MATERIALS HANDLING IN PUBLIC REFRIGERATED WAREHOUSES. U.S. Dept. Agr. Mktg. Res. Rpt. 145, 120 pp.

(2) BOGARDUS, R. K., and BURT, S. W.
1959. LOADING OUT FRUITS AND VEGETABLES IN WHOLESALE WAREHOUSES. U.S. Dept. Agr. Mktg. Res. Rpt. 282, 53 pp.

(3) _____ and FERRIS, R. T.
1961. RECEIVING FRUITS AND VEGETABLES IN WHOLESALE WAREHOUSES. U.S. Dept. Agr. Mktg. Res. Rpt. 478, 45 pp.

(4) CLOWES, H. G., ELLIOTT, W. H., and CROW, W. C.
1957. WHOLESALE FOOD MARKET FACILITIES. U.S. Dept. Agr. Mktg. Res. Rpt. 160, 96 pp.

(5) FERRIS, R. T., and BOGARDUS, R. K.
1964. STORING FRUITS AND VEGETABLES ON PALLETS IN WHOLESALE WAREHOUSES. U.S. Dept. Agr. Mktg. Res. Rpt. 622, 38 pp.

(6) LUNDQUIST, A. L., and BOUMA, J. C.
1968. THREE METHODS FOR LOADING OUT PRODUCE IN WAREHOUSES. U.S. Dept. Agr. Mktg. Res. Rpt. 665, 44 pp.

(7) U.S. DEPT. OF DEFENSE
1965. WAREHOUSING GROSS PERFORMANCE MEASUREMENT SYSTEM. Department of Defense (DOD 51.05.34-M)

☆ U.S. GOVERNMENT PRINTING OFFICE: 1973 O—501-701

Handling and Space Costs For Selected Food Wholesalers In Urban Food Distribution Centers

Marketing Research Report No. 992

Agricultural Research Service

UNITED STATES DEPARTMENT OF AGRICULTURE

PREFACE AND ACKNOWLEDGMENTS

This research was originally conducted by the former Transportation and Facilities Research Division, Agricultural Research Service, to help wholesalers located in multiple-occupancy buildings in urban food distribution centers to determine space, material-handling equipment requirements, and material-handling costs at different volumes of business. Optimization of these factors will enable wholesalers to keep food distribution costs down. To determine the nature and cost of material-handling systems in urban food distribution centers, the Transportation and Facilities Research Division contracted with St. Onge, Ruff and Associates, Inc., of York, Pa., to supply the data on which this report has been based. The contracting officer's designated representative was Marvin D. Volz. This type of research is being continued under the auspices of the Agricultural Marketing Research Institute, Agricultural Research Service.

The findings of this report are based on a substantial amount of data and computations. For reasons of economy, the data and computations have been omitted from this report. Wholesalers generally are interested only in research results. The supporting information may be obtained by contacting the authors.

Grateful appreciation is extended to the following food distribution centers and wholesale firms that contributed to this study:

Columbia State Farmers' Market, Columbia, S.C.:

Gomer Fruit Co.
C. B. Marchant Co.
L. R. Morris Co.
Senn Bros.
Stanley Produce

Georgia State Farmers' Market, Atlanta, Ga.:

John Camarata Co.
C. L. Fain Co.
J. W. Nash Co.
John F. Shipp Co.

New England Produce Center, Inc., Chelsea, Mass.:

A. Cavallaro Co., Inc.
P. Tavilla & Sons

Baltimore Wholesale Produce Market, Baltimore, Md.

Philadelphia Fresh Food Terminal Corp., Philadelphia, Pa.

CONTENTS

	Page
Summary	1
Introduction	2
Types of Firms Studied	3
Handling Systems	3
General	3
Equipment Use Description	4
Warehousing System	5
Loading In	5
Loading Out	5
Storage	9
Costs	11
Labor Costs	11
Equipment Costs	12
Cost Analysis	19
Complete-Line Produce Wholesaler	19
Specialty Produce Wholesaler	20
Fresh Poultry Wholesaler	20
Dairy and Egg Wholesaler	22
Literature Cited	24

Washington, D.C. Issued October 1973

For sale by the Superintendent of Documents, U.S. Government Printing Office,
Washington, D.C. 20402 - Price 40 cents
Stock Number 0100-02842

Handling and Space Costs For Selected Food Wholesalers In Urban Food Distribution Centers

By Marvin D. Volz, *industrial engineer*, Market Operations Research Laboratory, and James J. Karitas, *marketing specialist*, Food Distribution Research Laboratory, Northeastern Region, Agricultural Research Service

SUMMARY

This study developed handling and space costs for wholesalers of fresh fruits and vegetables, chill-pack poultry, dairy products, and eggs. These wholesalers operate in multiple-occupancy buildings by using three alternate handling methods at annual volume levels ranging from 1,000 to 60,000 tons. The three handling methods covered are: (1) pallets with manual pallet transporters, (2) pallets with electric pallet transporters, and (3) pallets using racks and counterbalanced electric forklift trucks. Costs were developed for each method at each selected volume level for labor, equipment, and space.

The most important findings were:

(1) Where a single module provides sufficient storage space with a one-pallet-high arrangement, manual pallet transporters produce the lowest total cost.

(2) When a single module, one-pallet-high arrangement does not provide sufficient storage space, it is more economical to store two or three pallets high using electric forklift trucks and racks than to rent a second module.

(3) The maximum annual tonnage that can be handled in a single module depends primarily on the density of the product, use of space, extent of seasonal volume variations, and the annual turnovers of inventory. To reach this maximum, products must be stacked three pallets high. Because the three-pallet-high arrangement requires a wider aisle for the forklift truck, and because products are not stacked as high on pallets in a three-pallet-high rack arrangement as they are with the one-pallet-high arrangement, the storage capacity of the three-high method is less than three times the capacity of the one-high method. The approximate annual volumes that can be handled in a single module using a one-pallet-high arrangement and a three-high arrangement are:

- 4,000 and 8,100 tons of fresh fruits and vegetables (complete line and specialty wholesalers).
- 8,500 and 17,200 tons of fresh poultry.
- 4,800 and 8,000 tons of dairy and egg products.

Annual savings using the forklift truck with three-tier racks instead of the electric pallet transporter with one-pallet-high stacking are as follows:

- For a complete-line produce wholesaler, $4,680 at the 6,000-ton level up to $43,800 at 60,000 tons.
- For a specialty produce wholesaler, $4,920 at the 6,000-ton level up to $42,000 at 60,000 tons.
- For a fresh poultry wholesaler, $4,310 at the 9,000-ton level up to $11,400 at 60,000 tons.
- For a dairy and egg wholesaler, $4,500 at the 6,000-ton level up to $35,400 at 60,000 tons.

INTRODUCTION

This research was undertaken to assist wholesalers who are operating in multiple-occupancy buildings in determining labor, equipment, and space costs at annual volumes ranging from 1,000 to 60,000 tons. The study was limited to four types of wholesalers: complete-line produce wholesalers, specialty produce wholesalers, fresh poultry wholesalers, and dairy and egg wholesalers.

In many urban areas, these wholesalers are located in modern distribution centers designed for receiving, handling, and distributing food efficiently. Wholesalers with varying size businesses in these centers operate in separate buildings suited to their needs, or in multiple-occupancy buildings—a type that houses more than one firm. The latter type is composed of 30- by 100-foot standard store units known as modules (fig. 1). The gross space consists of: storage, 2,160 sq. ft.; office, 600 sq. ft.; truck dock, 420 sq. ft.; and rail dock, 420 sq. ft. The grand total for the entire module is 3,600 sq. ft.

Most wholesalers perform the same basic operations, in that they receive, store, and load products. One marked difference is the extent to which wholesalers use mechanized handling equipment. Large wholesalers tend to use such equipment extensively, but small wholesalers do not.

Cost is the basis for evaluating whether or not a firm should use mechanized equipment. This study is an analysis of handling and space costs for powered and manual material-handling equipment used by food wholesalers at annual volumes from 1,000 to 60,000 tons.

Costs are developed for palletized operations using manual and electric pallet transporters and electric counterbalanced forklift trucks and pallet racks.

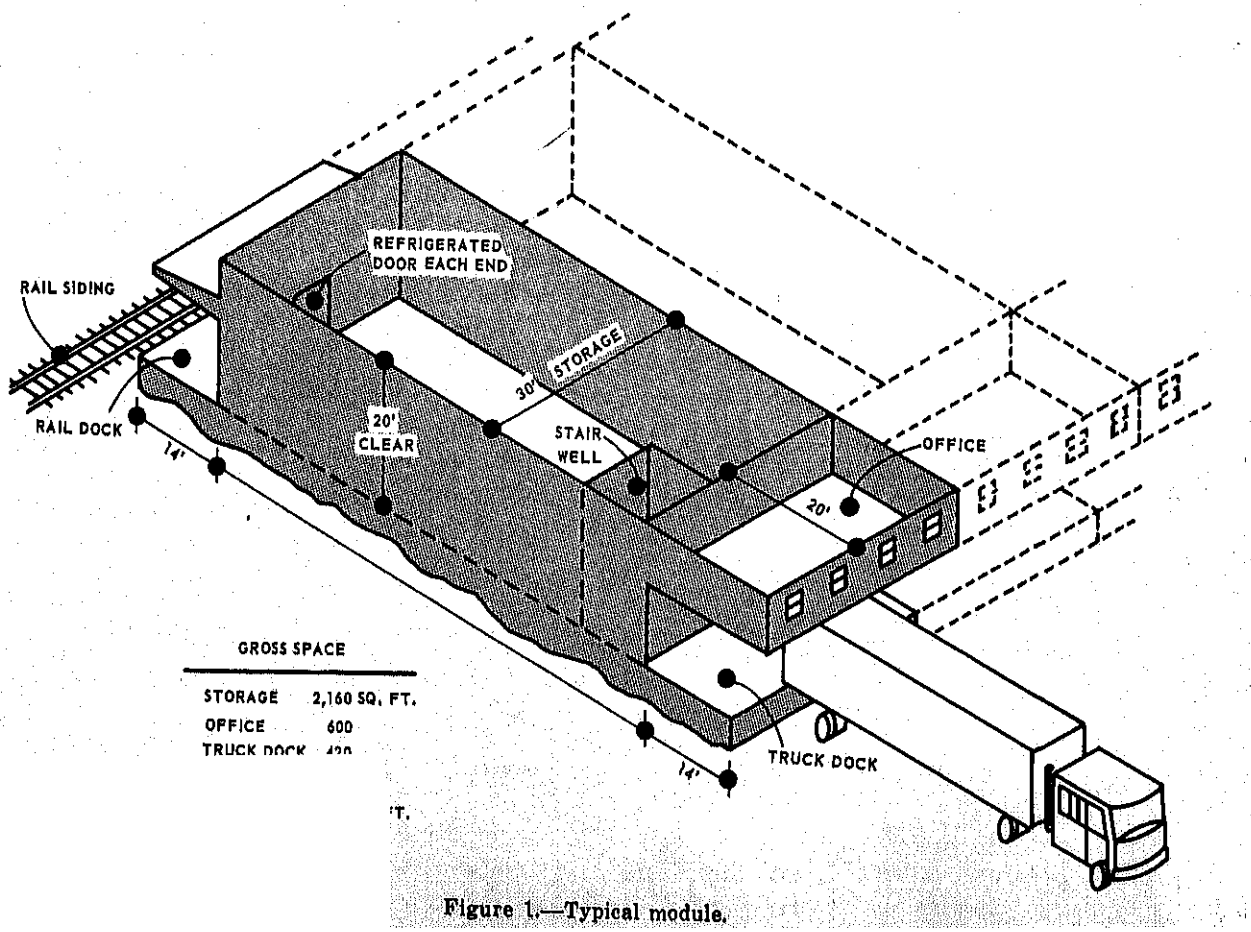

Figure 1.—Typical module.

TYPES OF FIRMS STUDIED

A complete-line produce wholesaler receives fresh fruits and vegetables in full and less than full carlot or trucklot quantities, primarily from producing areas where the products are grown. He sells to retail and institutional customers and other wholesalers. During the year, he deals in nearly all of the fruits and vegetables commonly sold in a supermarket.

A specialty wholesale firm handles three or less fresh fruit and vegetable products, and the complete-line produce wholesaler handles 20 or more. The specialty produce wholesaler turns over his inventory at the same rate as does the complete-line produce wholesaler (about 78 times annually), but since he handles substantially fewer items, his volume for each product is greater than the volume for the items handled by the complete-line produce wholesaler with a comparable total volume of business.

A fresh poultry wholesaler receives processed poultry in trucklot quantities, primarily from slaughtering and processing plants. His business comes from retail and institutional customers, and from other wholesalers.

This study of fresh poultry wholesalers includes poultry shipped in either "chill-pack" or frozen form rather than "icepack." "Chill-pack" poultry, often packaged either cut up or whole, is crust-frozen at the slaughter plant, shipped in refrigerated vehicles, and arrives at final destination slightly frozen. The package generally thaws in the refrigerated display case and presents an attractive, fresh appearance. Another method is packing dry ice in the shipping containers at the slaughter plant. The term "ice-pack" poultry refers to the practice of placing ice on the whole or cut-up poultry in the shipping container at the slaughter plant. The ice slowly melts on the way through distribution channels. However, enough ice is included to maintain a low temperature until final delivery to the retail or institutional customer.

The ice in "icepack" shipping containers gradually melts, which precludes high stacking because of the possibility of drippage from the top pallets contaminating the pallet loads below. Therefore, this analysis is confined to poultry shipped in chill-pack form.

The number of items handled by the fresh poultry wholesaler varies from six to eight. These items are primarily chicken products which the wholesaler receives in either 30- or 60-pound boxes. The time cycle from slaughtering through retail sale is approximately 13 days. The wholesaler, being somewhere in the middle of this cycle, is eager to keep product as fresh as possible, and therefore turns over his inventory frequently. Chill-pack poultry is inventoried for about 1 to 2 days, and a reasonable average inventory is 1½ days or 166 annual turnovers.

A dairy and egg wholesale firm receives products in carlot or trucklot quantities primarily from specialized suppliers, manufacturers, or processors. Customers are usually chainstores, retail food stores, and food service outlets.

Dairy products consist of 20 or more butter, margarine, and cheese items, and account for about one-half of the total annual business. An average inventory period is about 4 days, or approximately 63 inventory turnovers annually.

Eggs may consist of as many as six sizes and two grades, and account for the other half of this wholesaler's annual business. Compared with most dairy items, eggs are considerably more perishable, and consequently move through the distribution cycle more rapidly. An average inventory period is about 2 days or approximately 125 inventory turnovers annually. Average inventory turnover for a dairy and egg wholesaler would be 94 times annually.

HANDLING SYSTEMS

General

The labor involved in this study includes picking up pallet loads in the receiving operation, storing those loads, selecting products to fill customer orders, and taking that product to the shipping vehicle. It does not include the

INTRODUCTION

This research was undertaken to assist wholesalers who are operating in multiple-occupancy buildings in determining labor, equipment, and space costs at annual volumes ranging from 1,000 to 60,000 tons. The study was limited to four types of wholesalers: complete-line produce wholesalers, specialty produce wholesalers, fresh poultry wholesalers, and dairy and egg wholesalers.

In many urban areas, these wholesalers are located in modern distribution centers designed for receiving, handling, and distributing food efficiently. Wholesalers with varying size businesses in these centers operate in separate buildings suited to their needs, or in multiple-occupancy buildings—a type that houses more than one firm. The latter type is composed of 30- by 100-foot standard store units known as modules (fig. 1). The gross space consists of: storage, 2,160 sq. ft.; office, 600 sq. ft.; truck dock, 420 sq. ft.; and rail dock, 420 sq. ft. The grand total for the entire module is 3,600 sq. ft.

Most wholesalers perform the same basic operations, in that they receive, store, and load products. One marked difference is the extent to which wholesalers use mechanized handling equipment. Large wholesalers tend to use such equipment extensively, but small wholesalers do not.

Cost is the basis for evaluating whether or not a firm should use mechanized equipment. This study is an analysis of handling and space costs for powered and manual material-handling equipment used by food wholesalers at annual volumes from 1,000 to 60,000 tons.

Costs are developed for palletized operations using manual and electric pallet transporters and electric counterbalanced forklift trucks and pallet racks.

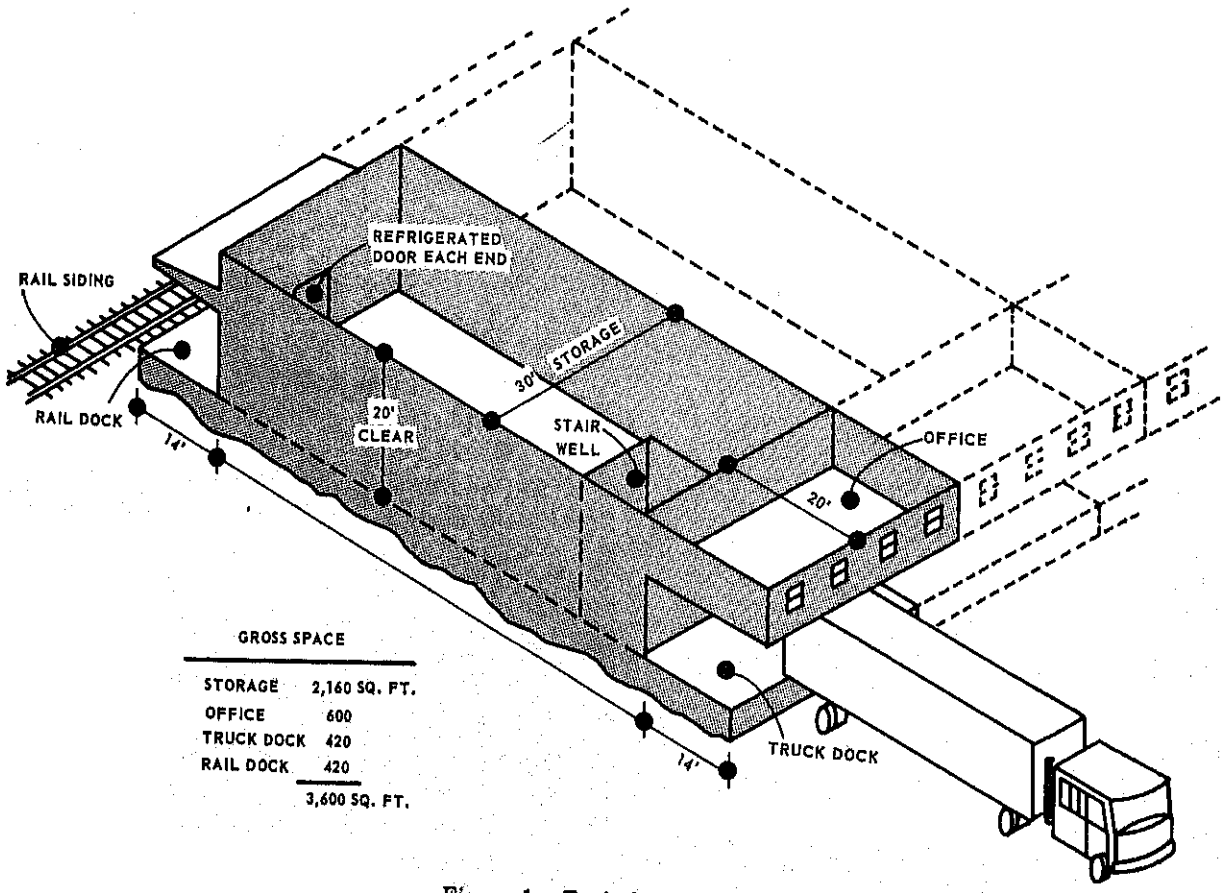

Figure 1.—Typical module.

TYPES OF FIRMS STUDIED

A complete-line produce wholesaler receives fresh fruits and vegetables in full and less than full carlot or trucklot quantities, primarily from producing areas where the products are grown. He sells to retail and institutional customers and other wholesalers. During the year, he deals in nearly all of the fruits and vegetables commonly sold in a supermarket.

A specialty wholesale firm handles three or less fresh fruit and vegetable products, and the complete-line produce wholesaler handles 20 or more. The specialty produce wholesaler turns over his inventory at the same rate as does the complete-line produce wholesaler (about 78 times annually), but since he handles substantially fewer items, his volume for each product is greater than the volume for the items handled by the complete-line produce wholesaler with a comparable total volume of business.

A fresh poultry wholesaler receives processed poultry in trucklot quantities, primarily from slaughtering and processing plants. His business comes from retail and institutional customers, and from other wholesalers.

This study of fresh poultry wholesalers includes poultry shipped in either "chill-pack" or frozen form rather than "icepack." "Chill-pack" poultry, often packaged either cut up or whole, is crust-frozen at the slaughter plant, shipped in refrigerated vehicles, and arrives at final destination slightly frozen. The package generally thaws in the refrigerated display case and presents an attractive, fresh appearance. Another method is packing dry ice in the shipping containers at the slaughter plant. The term "ice-pack" poultry refers to the practice of placing ice on the whole or cut-up poultry in the shipping container at the slaughter plant. The ice slowly melts on the way through distribution channels. However, enough ice is included to maintain a low temperature until final delivery to the retail or institutional customer.

The ice in "icepack" shipping containers gradually melts, which precludes high stacking because of the possibility of drippage from the top pallets contaminating the pallet loads below. Therefore, this analysis is confined to poultry shipped in chill-pack form.

The number of items handled by the fresh poultry wholesaler varies from six to eight. These items are primarily chicken products which the wholesaler receives in either 30- or 60-pound boxes. The time cycle from slaughtering through retail sale is approximately 13 days. The wholesaler, being somewhere in the middle of this cycle, is eager to keep product as fresh as possible, and therefore turns over his inventory frequently. Chill-pack poultry is inventoried for about 1 to 2 days, and a reasonable average inventory is 1½ days or 166 annual turnovers.

A dairy and egg wholesale firm receives products in carlot or trucklot quantities primarily from specialized suppliers, manufacturers, or processors. Customers are usually chainstores, retail food stores, and food service outlets.

Dairy products consist of 20 or more butter, margarine, and cheese items, and account for about one-half of the total annual business. An average inventory period is about 4 days, or approximately 63 inventory turnovers annually.

Eggs may consist of as many as six sizes and two grades, and account for the other half of this wholesaler's annual business. Compared with most dairy items, eggs are considerably more perishable, and consequently move through the distribution cycle more rapidly. An average inventory period is about 2 days or approximately 125 inventory turnovers annually. Average inventory turnover for a dairy and egg wholesaler would be 94 times annually.

HANDLING SYSTEMS

General

The labor involved in this study includes picking up pallet loads in the receiving operation, storing those loads, selecting products to fill customer orders, and taking that product to the shipping vehicle. It does not include the

actual building of pallet loads in the receiving operation, or the hand unloading of pallet loads delivered to the shipping vehicles.

For ease in computing handling labor needs, it was assumed that average daily sales and receipts would be equal. Although on a daily basis this balance between sales and receipts would not occur, the total amount of product handled in and out at specific volumes is the same, so the daily-average-handled method of computing labor requirements produces an accurate total-labor picture.

Equipment Use Description

Three types of material-handling equipment are analyzed separately to determine the cost per ton handled.

The manual pallet transporter (fig. 2) requires a minimum 5-foot 6-inch aisle to make a 90° turn while transporting a 48- by 40-inch pallet with fork entry into the 40-inch face.

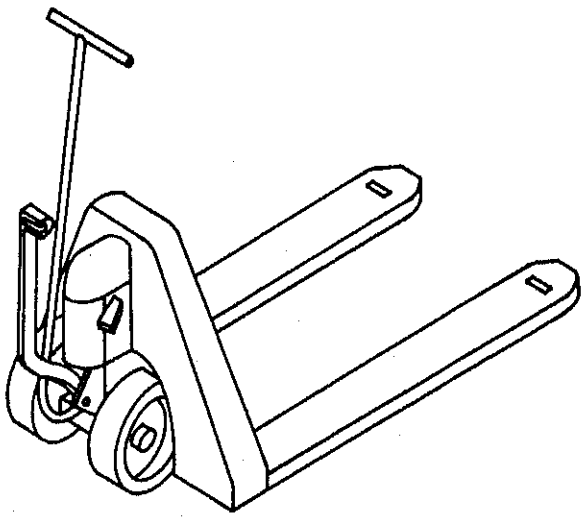

Figure 2.—3,000-pound manual pallet transporter.

The electric pallet transporter (fig. 3) requires a minimum 6-foot 4-inch aisle, since it is approximately 10 inches longer than the manual pallet transporter.

The counterbalanced forklift truck (fig. 4) differs in that it requires a minimum 9-foot 7-inch aisle to make its 90° turn.

The operating procedure is the same for each type of equipment during the loading-in operation. Pallet loads are picked up from the dock and taken to a designated storage location.

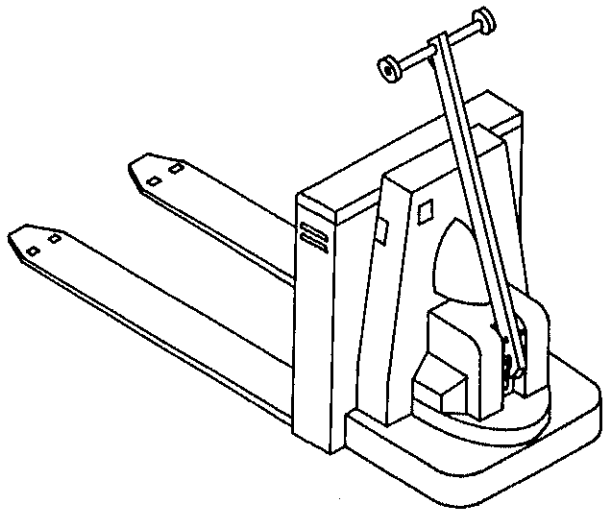

Figure 3.—3,000-pound electric pallet transporter.

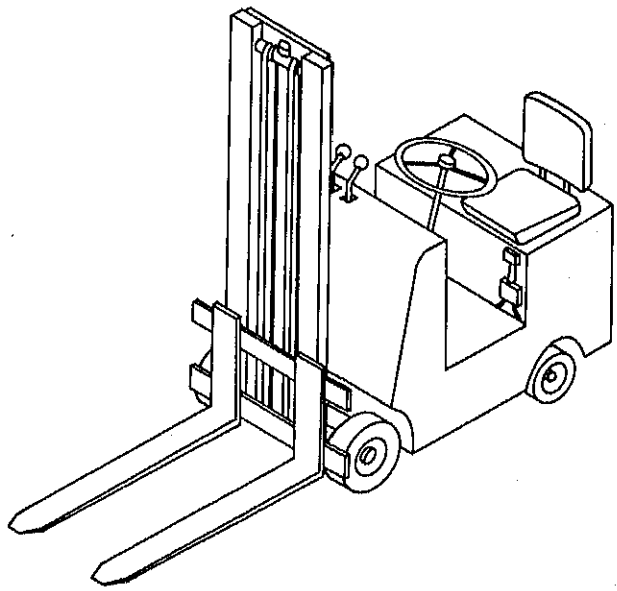

Figure 4.—3,000-pound counterbalanced forklift truck.

In the loading-out operation, the slow moving items are hand selected onto pallets within the warehouse and moved to the loading vehicles. The fast moving items are selected in the same manner until the travel distance and frequency of movement into and out of the warehouse becomes significant; then full-pallet loads of fast moving items are moved to the dock or assembly area. Here, orders are filled and delivered to shipping vehicles.

For example, the complete-line wholesale produce firm at the 9,000-ton volume and the specialty produce firm at the 6,000-ton volume hand select fast-moving items on the dock or assembly area. When forklifts are used for storage, economy is improved by using pallet transporters in the hand-selection operation in the warehouse and on the dock or assembly area.

The forklift, then, is used to move full-pallet loads into storage, directly to shipping vehicles and an assembly or dockhand selection area, and to restock slow moving items in the warehouse.

WAREHOUSING SYSTEM

An analysis of handling cost per ton using high-lift equipment (forklifts) and low-lift equipment (pallet transporters) necessitates that there be a frame of reference in which a comparison can be made. The equipment must operate within a system which produces the lowest cost per ton into and out of storage for each of the four types of wholesalers studied. Three interrelated functions are involved in the warehouse system: (1) Loading in; (2) loading out, and (3) storage.

Loading In

The loading-in function involves picking up pallet loads of products on the dock or in the receiving vehicle, transporting them to storage, and depositing them in designated locations. Since only full pallets are handled in the loading-in operation, productivity as measured in man-hours-per-ton is high compared with loading out, where less-than-full pallet loads are handled.

However, productivity of the loading-out function can be affected by the loading-in function. Pallets should be stocked in the quantities most frequently ordered by the wholesaler's customers. For example, if a significant number of orders are for 15 sacks of potatoes, and if pallets were being stacked with 20 sacks, double handling of 5 sacks per 15-sack order could be eliminated by stacking 15 sacks of potatoes per pallet during the loading-in operation.

Loading Out

For the small wholesale firm, customer orders are usually less than a full-pallet load of any one product. As a result, each order is filled by the warehouseman taking an empty pallet into the warehouse and selecting the quantities ordered of each product. The selected quantities are placed on the pallet, and when the order is filled, the pallet load of mixed product is taken to the shipping vehicle. Although the product packages, cases, or crates are of varying sizes and weights, the average pallet built in this manner weighs about 1,000 pounds or one-half ton. This process is called hand selection, and since it requires the handling of individual cases rather than full-pallet loads, tons per man-hour are considerably less than in the loading-in process, where each product is handled in full-pallet loads.

In contrast, large wholesale firms' customer orders need not be exclusively filled by the hand-selection process. Studies in the field show that approximately 80 percent of the volume shipped comes from 20 percent of the items warehoused. These are the fast moving items, and as volume increases from between 6,000-9,000 (depending upon the specific wholesale firm) to 60,000 tons, orders for these items can be partly filled by full-pallet loads. For instance, a customer's order includes 50 sacks of potatoes. Potatoes are stacked 20 to a pallet. The wholesaler moves 2 pallet loads to the truck and hand selects the remaining 10 sacks to satisfy that item of the order.

To hold down the distance that hand selectors must travel in filling less than full-pallet orders for the fast moving items, pallet loads are taken to the dock or assembly area adjacent to the dock. In this manner the use of full pallets to satisfy customer orders and to replenish picking stock in the dock or assembly area produces greater productivity than hand selection in the warehouse. Hand selection in the warehouse would continue to be used for the slow moving items. The distribution of daily volume by load-out function for specific wholesalers is shown in tables 1, 2, 3, 4, and 5.

The complete-line produce wholesaler does not begin to move full-pallet loads from the storage area to the loading dock to any appreciable extent until the 9,000-ton annual volume level is reached. The percentage of daily volume transported as full pallets to the loading dock ranges from 12 percent at the 9,000-ton level to 40 percent at 60,000 tons. The volume selected in the assembly area ranges from 68 percent at the 9,000-ton level to 40 percent at 60,000 tons. Up to the 6,000-ton level, 100 percent is hand selected in the storage area. Above the 6,000-ton level, 20 percent is hand selected in the storage area (table 1).

The specialty produce wholesaler begins to move 12 percent of his daily volume as full pallets at the 6,000-ton level, and the percentage increases to 40 at the 60,000-ton level. The volume selected in the assembly area ranges from 88 percent at the 6,000-ton level to 60 percent at 60,000 tons. Up to the 3,000-ton level, 100 percent of the daily volume is hand selected in the storage area. Above the 6,000-ton level, there is no hand selection of product in the storage area (table 2).

The fresh poultry wholesaler moves 12 percent of his daily volume as full pallets at the 6,000-ton level, and the percentage increases to 40 at the 60,000-ton level. Volume selected in the assembly area ranges from 88 percent at the 6,000-ton level to 60 percent at 60,000 tons. Up to the 3,000-ton level, all hand selection is performed in the storage area. Above the 3,000-ton level, there is no hand selection of products in the storage area (table 3).

The dairy and egg wholesaler's annual volume is equally divided between dairy and egg products. At the 7,500-ton level, 13.7 percent of the daily volume of dairy products is transported as full pallets from storage to the loading dock, and the percentage increases to 32 at the 30,000-ton level. The volume selected in the assembly area ranges from 66.3 percent at 7,500 tons to 48.0 percent at 30,000 tons. Up to the 6,000-ton level, 100 percent of the volume is hand selected in the storage area. Above 6,000 tons, 20 percent of the daily volume is hand selected in the storage area (table 4).

The dairy and egg wholesaler moves 12 percent of the daily volume of eggs directly to the loading dock as full-pallet loads at the 6,000-ton

TABLE 1.—*Distribution of daily volume by load-out method for complete-line produce wholesaler* [1]

Annual volume	Daily volume							
	Total volume	Full pallets to docks [2]		Volume selected in assembly area		Volume hand selected in storage	
Tons	*Tons*	*Percent*	*Tons*	*Percent*	*Tons*	*Percent*	*Tons*
1,000	4	------	------	------	------	100.0	4
2,000	8	------	------	------	------	100.0	8
3,000	12	------	------	------	------	100.0	12
6,000	24	------	------	------	------	100.0	24
9,000	36	12.0	4.3	68.0	24.5	20.0	7.2
12,000	48	16.0	7.7	64.0	30.7	20.0	9.6
15,000	60	20.0	12.0	60.0	36.0	20.0	12.0
30,000	120	32.0	38.4	48.0	57.6	20.0	24.0
60,000	240	40.0	96.0	40.0	96.0	20.0	48.0

[1] Complete-line produce wholesaler who handles 20 or more fresh fruit and vegetable items.

[2] The number of full-pallet loads moving to the docks below the 9,000-ton level was negligible.

TABLE 2.—*Distribution of daily volume by load-out method for specialty produce wholesaler* [1]

Annual volume	Daily volume						
	Total volume	Full pallets to docks [2]		Volume selected in assembly area		Volume hand selected in storage	
Tons	*Tons*	*Percent*	*Tons*	*Percent*	*Tons*	*Percent*	*Tons*
1,000	4					100.0	4
2,000	8					100.0	8
3,000	12					100.0	12
6,000	24	12.0	2.9	88.0	21.1	0	0
9,000	36	16.0	5.8	84.0	30.2	0	0
12,000	48	20.0	9.6	80.0	38.4	0	0
15,000	60	24.0	14.4	76.0	45.6	0	0
30,000	120	32.0	38.4	68.0	81.6	0	0
60,000	240	40.0	96.0	60.0	144.0	0	0

[1] Specialty produce wholesaler who handles three or less fresh fruit and vegetable items.

[2] The number of full-pallet loads moving to the docks below the 6,000-ton level was negligible.

TABLE 3.—*Distribution of daily volume by load-out method for fresh poultry wholesaler*

Annual volume		Daily volume					
	Total volume	Full pallets to docks [1]		Volume selected in assembly area		Volume hand selected in storage	
Tons	*Tons*	*Percent*	*Tons*	*Percent*	*Tons*	*Percent*	*Tons*
1,000	4					100.0	4
2,000	8					100.0	8
3,000	12					100.0	12
6,000	24	12.0	2.9	88.0	21.1	0	0
9,000	36	16.0	5.8	84.0	30.2	0	0
12,000	48	20.0	9.6	80.0	38.4	0	0
15,000	60	24.0	14.4	76.0	45.6	0	0
30,000	120	32.0	38.4	68.0	81.6	0	0
60,000	240	40.0	96.0	60.0	144.0	0	0

[1] The number of full-pallet loads moving to the docks below the 6,000-ton level was negligible.

level, and the percentage increases to 32 at the 30,000-ton level. The volume selected in the assembly area ranges from 88 percent at 6,000 tons to 68 percent at 30,000 tons. Below 6,000 tons, all hand selection is performed in the storage area. At 6,000 tons and above, there is no hand selection of products in the storage area (table 5).

TABLE 4.—*Distribution of daily volume by load-out method for dairy and egg wholesaler*
(Dairy products)

Annual volume	Daily volume						
	Total volume	Full pallets to docks [1]		Volume selected in assembly area		Volume hand selected in storage	
Tons	*Tons*	*Percent*	*Tons*	*Percent*	*Tons*	*Percent*	*Tons*
500	2					100.0	2
1,000	4					100.0	4
1,500	6					100.0	6
3,000	12					100.0	12
4,500	18					100.0	18
6,000	24					100.0	24
7,500	30	13.7	4.1	66.3	19.9	20.0	6
15,000	60	20.0	12.0	60.0	36.0	20.0	12
30,000	120	32.0	38.4	48.0	57.6	20.0	24

[1] The number of full-pallet loads moving to the docks below the 7,500-ton level was negligible.

TABLE 5.—*Distribution of daily volume by load-out method for dairy and egg wholesaler*
(Eggs)

Annual volume	Daily volume						
	Total volume	Full pallets to docks [1]		Volume selected in assembly area		Volume hand selected in storage	
Tons	*Tons*	*Percent*	*Tons*	*Percent*	*Tons*	*Percent*	*Tons*
500	2					100.0	2
1,000	4					100.0	4
1,500	6					100.0	6
3,000	12					100.0	12
4,500	18					100.0	18
6,000	24	12.0	2.9	88.0	21.1	0	0
7,500	30	13.7	4.1	86.3	25.9	0	0
15,000	60	24.0	14.4	76.0	45.6	0	0
30,000	120	32.0	38.4	68.0	81.6	0	0

[1] The number of full-pallet loads moving to the docks below the 6,000-ton level was negligible.

Storage

In a warehouse system, storage is the temporary interruption of the flow of product from receiving to shipping. Storage space provides a place for received products to be kept until customer orders are taken, and the products are shipped.

Space required for storage is determined by the size of the unit load, the amount of inventory, and the arrangement of unit loads in storage. The unit load used in this study is a four-way entry pallet, 48″ x 40″, which can be oriented parallel to the aisle with either dimension.

It was observed that the weight of pallet loads stored one high averaged 1,500 pounds, and that pallet loads used in three-tier racks averaged 1,250 pounds.

Ideally, inventory would equal the next day's sales. It is unlikely that the wholesale food business will ever operate under this ideal situation, because it would be nearly impossible to purchase products from suppliers in varying amounts and expect daily deliveries. Even if it were possible, the cost of purchasing small quantities (1 day's supply) would be prohibitive. In actual practice, inventory represents several days' supply of products governed by price, discounts, specific quantities purchased, delivery time from suppliers, the perishability of the product, and demand. The fresh fruit and vegetable wholesaler maintains an average inventory equal to an average 3.2 days' sales or 78 turnovers annually. The poultry wholesaler turns his inventory 166 times a year, and the dairy and egg wholesaler 94 times a year.

Average inventory is determined by dividing the number of turnovers into the annual volume. For example, a fruit and vegetable firm whose annual volume is 4,000 tons with 78 turnovers would have an average inventory of 51.2 tons, or 102,400 pounds. This method of determining the average inventory is useful in establishing space requirements. Although seasonal variations in sales volume will result in the average inventory being exceeded, adjustments in pallet arrangements within a given space can accommodate changing inventory requirements.

For example, figure 5A illustrates a one-high pallet arrangement with a total of 68 pallets in one module. This arrangement is ideal for selection of products, because 55 of the 68 pallet positions are immediately accessible from the aisles. Figure 5B shows a one-high pallet arrangement with 86 pallets in one module. This arrangement is not as desirable for product selection, because only 34 of the 86 pallet positions are immediately accessible from the aisle, but the storage density is greatly improved over figure 5A.

Pallet storage above the one-high arrangement increases the number of pallets and pounds of product which can be stored in the typical module. By using a three-tier rack arrangement as illustrated in figure 5C, the wholesaler can increase the number of pallet positions to 207, or to about 2½ (2.41) times the number which can be stored one high. Of the 207 pallet positions, 54 faces are above floor level. This increase is not directly proportional, as the three-tier terminology might imply, because more aisle space is required for the forklift than for pallet transporters, and the rack structures use additional floorspace. The increase in pounds stored is about 2.01 times the pounds stored in the one-high arrangement, because the weight of each pallet is less with the rack arrangement than with the alternate method.

Under most warehousing situations, the number of loaded pallets in storage at any given time is somewhat less than the number that could be stored, because there is seldom a perfect daily balance between receipts and shipments. Moreover, products are stored in the unit load of a pallet. As customer orders are selected in less-than-pallet quantities, some pallets in storage will be less than full-pallet loads. These conditions limit warehouse storage occupancy to between 70 and 90 percent of calculated potential storage capacity, or to an average occupancy of 80 percent.

The calculated pallet capacity for the one-high arrangement in figure 5B was 86. With an 80-percent occupancy factor, the expected operating capacity would be equivalent to 68 full-pallet loads, or to approximately 102,000 pounds (68 pallets times 1,500 pounds per pallet). Since the 102,000 pounds constitute the

expected operating inventory, the number of turnovers multiplied by 102,000 pounds produces the approximate annual volume of business that a single module could sustain. Assuming that the wholesaler experienced 78 annual turnovers, as is typical of the fresh fruit and vegetable firm as well as the specialty wholesaler, one would estimate approximately 8 million pounds or 4,000 tons of annual business from a single module using the one-high ar-

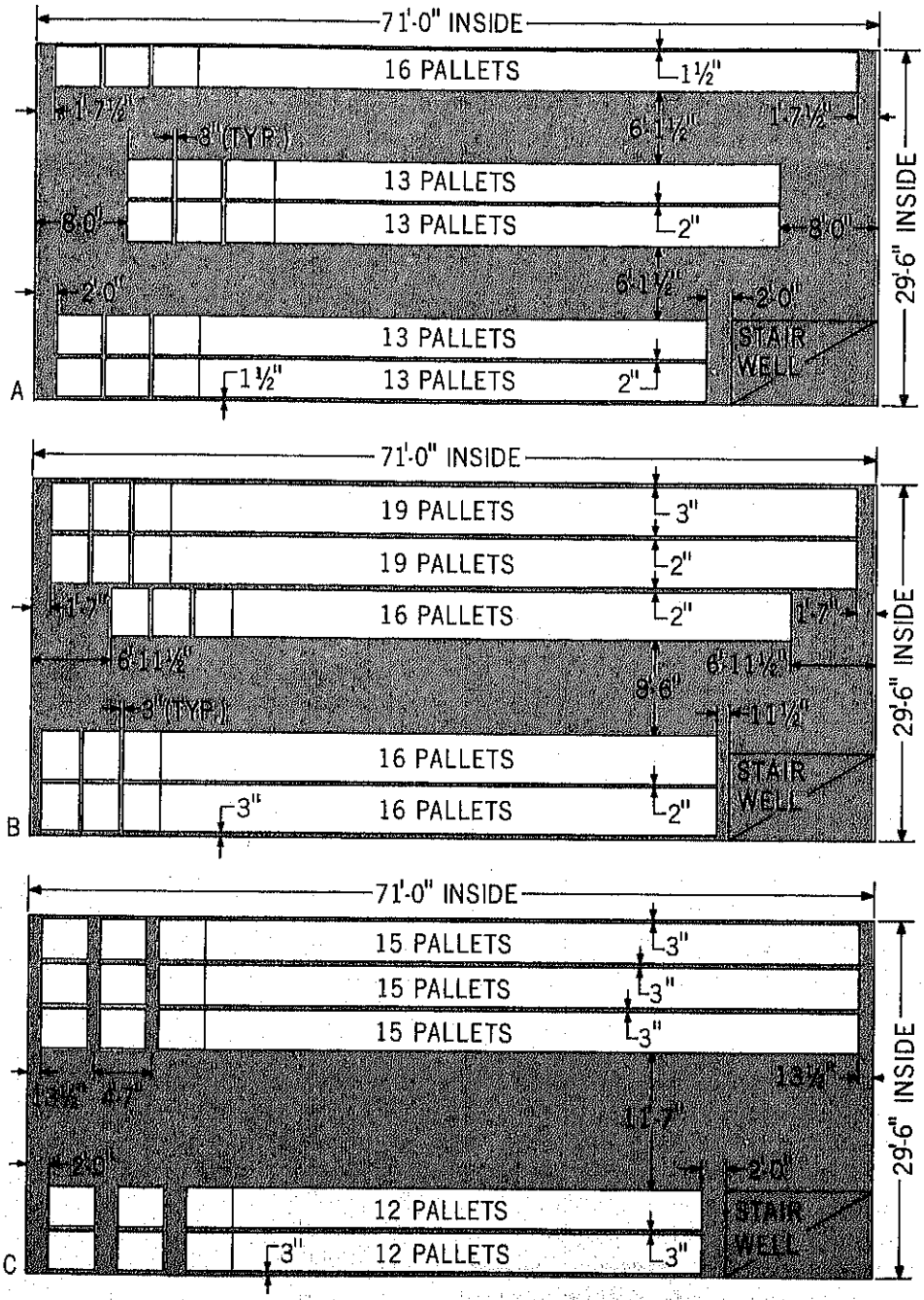

Figure 5.—40-inch by 48-inch pallet arrangement; *A*, 68 one-pallet-high storage; *B*, 86 one-pallet-high storage; *C*, three-tier pack arrangement, 207 one-pallet-high storage.

rangement. On the same 80-percent-occupancy basis using the three-tier rack arrangement shown in figure 5C, the expected operating capacity would be equivalent to 166 full-pallet loads, or to approximately 207,500 pounds (166 pallets times 1,250 pounds per pallet).

Again, the average inventory of 207,500 pounds was multiplied by the number of annual turnovers (78). The result, 16,185,000 pounds, or approximately 8,100 tons, represented the annual volume of business which could be generated from one module by using a 3-tier rack arrangement.

A poultry wholesaler with an average of 166 turnovers a year could handle about 8,500 tons of product in a single module by using the pallet transporter and one-high pallet-stacking arrangement as shown in figure 5B. Using the forklift truck and three-tier rack arrangement as shown in figure 5C, a poultry wholesaler could handle approximately 17,200 tons of product a year.

A dairy and egg wholesaler with an average of 94 turnovers a year could handle about 4,800 tons of product in a single module using the pallet transporter and one-high stacking arrangement. Using the forklift truck and 3-tier rack arrangement, the dairy and egg wholesaler could handle approximately 8,000 tons of product a year.

COSTS

Labor, handling equipment, and rent costs are included, but management, refrigeration, and utility costs are not included in the study. Labor costs are computed for the productive time involved in the handling of product, including fatigue and personal allowances based on an annual wage rate of $7,800, or $3.90 per hour. That is, if the total time required to handle a wholesaler's product into and out of storage on a daily basis takes 5 hours, only 5 hours are charged to the handling cost. It is assumed that the remaining hours in the working day can be put to productive use in some function other than handling product.

Equipment cost includes owning and operating expenses over the useful life of the equipment. Rent costs are computed on the basis of $2 per square foot. In a typical module, there are 3,000 square feet of floorspace including the dock areas, and 600 feet of office space over the truck dock, a total of 3,600 square feet, or an annual rental of $7,200. It is assumed that only complete modules can be rented.

Labor Costs

Labor costs were developed from time studies conducted during normal working hours in firms located in multiple-occupancy buildings in five distribution centers. In addition, part of the data was adapted from previously published studies by the Transportation and Facilities Research Division and from related sources. For a complete listing, see Literature Cited, page 24.

A wage rate of $3.90 per hour, including fringe benefits, was applied to the man-hour labor requirements developed for the various methods studied.

Loading in consists of picking up loaded pallets on the receiving dock and placing them in storage. To develop labor requirements for the loading-in function, the operation was broken down into four elements:

(1) Pick up loaded pallet.
(2) Travel to storage area.[1]
(3) Place loaded pallet into proper storage location.
(4) Return to receiving dock.

Loading out consists of assembling products in quantities corresponding to customer orders and transporting the loaded pallets to the loading dock. Three basic loading-out methods were used:

Method A—Hand selection in the storage area.

Method B—Hand selection in an order selection area.

Method C—Selecting full-pallet loads in the storage area.

To determine labor requirements for the loading-out function, the operation was broken

[1] Travel distance for both the load-in and load-out function varied according to number of units required at different volume levels.

down into the following elements for the three methods:

Method A—Hand selection in the storage area:

(1) Travel from dock to storage area.
(2) Select cases, place on pallets, and travel between selection points.
(3) Travel from storage area to loading dock.
(4) Place loaded pallet on loading dock.

Method B—Hand selection in an order assembly area:

(1) Travel from loading dock to storage area.
(2) Pick up full pallets of fast moving items.
(3) Transport full pallets and place in assembly area.
(4) Travel from dock to assembly area.
(5) Select cases, place on pallets, and travel between selection points.
(6) Transport loaded pallets and place on loading dock.

Method C—Selecting full-pallet loads in the storage area:

(1) Travel from dock to storage area.
(2) Pick up full pallets from storage location.
(3) Transport full pallets and place on loading dock.

The degree to which Methods A, B, and C are used for loading out depends on the quantities of product that move as full-pallet loads directly to the dock, quantities that are selected in the assembly area, and the amount of product selected in the storage area. The quantities of product handled by Methods A, B, and C can be found in tables 1 through 5. The degree of use shown in these tables was used in computing the total labor cost of the load-out function.

The man-hour requirements and labor costs per ton for the four types of wholesalers using the three handling methods at the various volume levels are shown in tables 6 through 9.

Equipment Costs

Equipment costs were determined by examining equipment requirements at each volume level, developing annual ownership and maintenance costs for the equipment, and dividing these costs by the annual volume to compute the cost per ton.

The number of pallet transporters, as well as the number of forklift trucks, was determined by comparing the daily man-hours required to perform the loading-in and loading-out functions. This number was then divided by 8 hours to obtain the amount of handling equipment need on a one-shift basis.

The number of pallets and the number of rack positions were determined by dividing the annual tonnage by the annual inventory turnover rate to obtain the average tons per turnover. This quotient (average tons per turnover) was in turn divided by the average tons of product stacked on the pallet to determine the number of pallets and rack positions. An allowance was also made for extra pallets at each volume level for use in order assembly.

Annual cost consists of depreciation, interest, taxes, insurance, and maintenance. Depreciation on equipment is based on Federal recommended depreciation periods of 8 years or 12 percent of the initial investment. Interest is based on 8 percent annual cost of undepreciated balance, or 4 percent of initial cost. Taxes and insurance are computed at 4 percent. Maintenance costs at 2½ percent are based on experience, and may vary from operator to operator. The total annual ownership and maintenance costs used in this study are equivalent to 23 percent of the initial investment cost for each type of equipment.

The equipment cost figures outlined below were furnished by manufacturers and were current for 1970.

3,000-lb. manual pallet transporter	$350
3,000-lb. electric pallet transporter, including battery and charger	2,550
3,000-lb. counterbalance forklift truck, including battery and charger	9,000
Storage racks, per pallet position	15
Single-faced hardwood pallets, 40″ x 48″ or 48″ x 40″	4

The equipment requirements, annual costs, and the cost per ton for the three handling methods at the selected volume levels for the four types of wholesalers are shown in tables 10 through 13.

TABLE 6.—*Man-hour requirements and labor costs per ton for loading in and loading out for complete-line produce wholesaler*

Annual volume	Manual pallet transporter[1]				Electric pallet transporter[1]				Counterbalanced forklift truck[1]			
	Loading in	Loading out	Total time	Total labor cost	Loading in	Loading out	Total time	Total labor cost	Loading in	Loading out	Total time	Total labor cost
Tons	*Man-hours*	*Man-hours*	*Man-hours*	*Dollars*	*Man-hours*	*Man-hours*	*Man-hours*	*Dollars*	*Man-hours*	*Man-hours*	*Man-hours*	*Dollars*
1,000	0.047	0.139	0.186	0.73	0.026	0.135	0.161	0.63	0.038	0.137	0.175	0.68
2,000	.044	.139	.183	.71	.024	.135	.159	.62	.035	.137	.172	.67
3,000	.042	.139	.181	.71	.023	.135	.158	.62	.036	.137	.173	.68
6,000	.043	.142	.185	.72	.025	.137	.162	.63	.034	.136	.170	.66
9,000	.045	.099	.144	.56	.026	.079	.105	.41	.036	.082	.118	.46
12,000	.045	.097	.142	.55	.026	.077	.103	.40	.036	.081	.117	.46
15,000	.047	.096	.143	.56	.027	.077	.104	.41	.036	.077	.113	.44
30,000	.053	.094	.147	.57	.034	.075	.109	.43	.038	.072	.110	.43
60,000	.065	.101	[2].166	.65	.044	.082	[2].126	.49	.042	.072	[2].114	.44

[1] Loading in includes time to pick up loaded pallet at tailgate of incoming vehicle, travel to storage, place in storage, and return to dock. Loading out consists of the functions involved in order assembly and transporting orders to loading dock. Total labor cost based on a rate of $3.90 per hour including fringe benefits.

[2] Increase in labor time at the 60,000-ton level is due to the substantial increase in travel distance because of the large number of modules required.

TABLE 7.—*Man-hour requirements and labor costs per ton for loading in and loading out for specialty-line produce wholesaler*

Annual volume	Manual pallet transporter [1]				Electric pallet transporter [1]				Counterbalanced forklift truck [1]			
	Loading in	Loading out	Total time	Total labor cost	Loading in	Loading out	Total time	Total labor cost	Loading in	Loading out	Total time	Total labor cost
Tons	*Man-hours*	*Man-hours*	*Man-hours*	*Dollars*	*Man-hours*	*Man-hours*	*Man-hours*	*Dollars*	*Man-hours*	*Man-hours*	*Man-hours*	*Dollars*
1,000	0.047	0.139	0.186	0.73	0.026	0.135	0.161	0.63	0.038	0.137	0.175	0.68
2,000	.044	.139	.183	.71	.024	.135	.159	.62	.035	.137	.172	.67
3,000	.042	.139	.181	.71	.023	.135	.158	.62	.036	.137	.173	.68
6,000	.043	.087	.130	.51	.025	.063	.088	.34	.035	.067	.102	.40
9,000	.045	.092	.137	.53	.026	.062	.088	.34	.036	.066	.102	.40
12,000	.045	.083	.128	.50	.026	.060	.086	.34	.036	.065	.101	.39
15,000	.047	.082	.129	.50	.028	.059	.087	.34	.036	.061	.097	.38
30,000	.053	.084	.137	.53	.034	.061	.095	.37	.038	.060	.098	.38
60,000	.065	.090	[2].155	.60	.044	.067	[2].111	.43	.042	.059	[2].101	.39

[1] Loading in includes time to pick up loaded pallet at tailgate of incoming vehicle, travel to storage, place in storage, and return to dock. Loading out consists of the functions involved in order assembly and transporting orders to loading dock. Total labor cost based on a rate of $3.90 per hour including fringe benefits.

[2] Increase in labor time at the 60,000-ton level is due to the substantial increase in travel distance because of the large number of modules required.

TABLE 8.—*Man-hour requirements and labor cost per ton for loading in and loading out for fresh poultry wholesaler*

Annual volume	Manual pallet transporter [1]				Electric pallet transporter [1]				Counterbalanced forklift truck [1]			
	Loading in	Loading out	Total time	Total labor cost	Loading in	Loading out	Total time	Total labor cost	Loading in	Loading out	Total time	Total labor cost
Tons	*Man-hours*	*Man-hours*	*Man-hours*	*Dollars*	*Man-hours*	*Man-hours*	*Man-hours*	*Dollars*	*Man-hours*	*Man-hours*	*Man-hours*	*Dollars*
1,000	0.047	0.139	0.186	0.73	0.026	0.135	0.161	0.63	0.038	0.137	0.175	0.68
2,000	.044	.139	.183	.71	.024	.135	.159	.62	.035	.137	.172	.67
3,000	.042	.139	.181	.71	.023	.135	.158	.62	.036	.137	.173	.68
6,000	.041	.086	.127	.50	.020	.062	.085	.33	.035	.068	.103	.40
9,000	.043	.085	.128	.50	.025	.061	.086	.34	.035	.065	.100	.39
12,000	.043	.082	.125	.49	.025	.059	.084	.33	.035	.063	.098	.38
15,000	.043	.080	.123	.48	.026	.058	.084	.33	.035	.060	.095	.37
30,000	.047	.077	.124	.48	.027	.056	.083	.32	.036	.052	.088	.34
60,000	.051	.070	[2].128	.50	.031	.054	[2].085	.33	.038	.055	[2].093	.36

[1] Loading in includes time to pick up loaded pallet at tailgate of incoming vehicle, travel to storage, place in storage, and return to dock. Loading out consists of the functions involved in order assembly and transporting orders to loading dock. Total labor cost based on a rate of $3.90 per hour including fringe benefits.

[2] Increase in labor time at the 60,000-ton level is due to the substantial increase in travel distance because of the large number of modules required.

TABLE 9.—*Man-hour requirements and labor cost per ton for loading in and loading out for dairy and egg wholesaler*

Annual volume	Manual pallet transporter [1]				Electric pallet transporter [1]				Counterbalanced forklift truck [1]			
	Loading in	Loading out	Total time	Total labor cost	Loading in	Loading out	Total time	Total labor cost	Loading in	Loading out	Total time	Total labor cost
Tons	*Man-hours*	*Man-hours*	*Man-hours*	*Dollars*	*Man-hours*	*Man-hours*	*Man-hours*	*Dollars*	*Man-hours*	*Man-hours*	*Man-hours*	*Dollars*
1,000	0.047	0.139	0.186	0.73	0.026	0.135	0.161	0.63	0.038	0.137	0.175	0.68
2,000	.044	.139	.183	.71	.024	.135	.159	.62	.035	.137	.172	.67
3,000	.042	.139	.181	.71	.023	.135	.158	.62	.036	.137	.173	.68
6,000	.043	.142	.185	.72	.025	.137	.162	.63	.035	.137	.172	.67
9,000	.043	.143	.186	.73	.025	.136	.161	.63	.035	.136	.171	.67
12,000	.045	.115	.160	.62	.026	.100	.126	.49	.036	.102	.138	.54
15,000	.045	.094	.139	.54	.026	.071	.097	.38	.036	.074	.110	.43
30,000	.050	.092	.142	.55	.030	.070	.100	.39	.037	.070	.107	.42
60,000	.060	.096	[2].156	.61	.040	.076	[2].116	.45	.040	.068	[2].108	.42

[1] Loading in includes time to pick up loaded pallet at tailgate of incoming vehicle, travel to storage, place in storage, and return to dock. Loading out consists of the functions involved in order assembly and transporting orders to loading dock. Total labor cost based on a rate of $3.90 per hour including fringe benefits.

[2] Increase in labor time at the 60,000-ton level is due to the substantial increase in travel distance because of the large number of modules required.

TABLE 10.—*Equipment requirements and annual ownership and maintenance costs per ton for complete-line produce wholesaler*

Annual volume	Pallets required	Manual pallet transporter method				Electric pallet transporter method					Counterbalanced forklift truck method					
		Transporters required	Total initial cost [1]	Annual cost [2]	Cost per ton	Transporters required	Total initial cost [1]	Annual cost [2]	Cost per ton	Pallets required	Electric pallet transporters required	Forklift trucks required	Racks required	Total initial cost [1]	Annual cost [2]	Cost per ton
Tons	*Number*	*Number*	*Dollars*	*Dollars*	*Dollars*	*Number*	*Dollars*	*Dollars*	*Dollars*	*Number*	*Number*	*Number*	*Number*	*Dollars*	*Dollars*	*Dollars*
1,000	19	1	426.00	98.00	0.10	1	2,626.00	604.00	0.60	23	———	1	21	9,407.00	2,163.00	2.16
2,000	38	1	502.00	115.00	.06	1	2,702.00	621.00	.31	46	———	1	42	9,814.00	2,257.00	1.13
3,000	57	1	578.00	133.00	.04	1	2,778.00	639.00	.21	69	———	1	63	10,221.00	2,351.00	.78
6,000	112	1	798.00	184.00	.03	1	2,998.00	690.00	.12	133	———	1	123	11,377.00	2,617.00	.44
9,000	166	2	1,364.00	314.00	.04	1	3,214.00	739.00	.08	195	1	1	183	15,075.00	3,467.00	.39
12,000	220	2	1,580.00	363.00	.03	2	5,980.00	1,375.00	.12	262	1	1	246	16,288.00	3,747.00	.31
15,000	276	3	2,154.00	495.00	.04	2	6,204.00	1,427.00	.10	326	1	1	306	17,444.00	4,012.00	.27
30,000	542	5	3,918.00	901.00	.03	4	12,368.00	2,845.00	.10	645	2	2	615	34,905.00	8,028.00	.27
60,000	1,064	10	7,756.00	1,784.00	.03	8	24,656.00	5,671.00	.10	1,270	3	4	1,230	67,180.00	15,451.00	.26

[1] Includes cost of manual pallet transporter at $350 each; electric pallet transporter at $2,550 each; counterbalanced forklift truck at $9,000 each; racks at $15 per pallet storage position, and pallets at $4 each.
[2] Based on 23 percent of initial cost, which includes depreciation, interest, taxes, insurance, and maintenance.

TABLE 11.—*Equipment requirements and annual ownership and maintenance costs per ton for specialty produce wholesaler*

Annual volume	Pallets required	Manual pallet transporter method				Electric pallet transporter method					Counterbalanced forklift truck method					
		Transporters required	Total initial cost [1]	Annual cost [2]	Cost per ton	Transporters required	Total initial cost [1]	Annual cost [2]	Cost per ton	Pallets required	Electric pallet transporters required	Forklift trucks required	Racks required	Total initial cost [1]	Annual cost [2]	Cost per ton
Tons	*Number*	*Number*	*Dollars*	*Dollars*	*Dollars*	*Number*	*Dollars*	*Dollars*	*Dollars*	*Number*	*Number*	*Number*	*Number*	*Dollars*	*Dollars*	*Dollars*
1,000	19	1	426.00	98.00	0.10	1	2,626.00	604.00	0.60	23	———	1	21	9,407.00	2,163.00	2.16
2,000	38	1	502.00	115.00	.06	1	2,702.00	621.00	.31	46	———	1	42	9,814.00	2,257.00	1.13
3,000	57	1	578.00	133.00	.04	1	2,778.00	639.00	.21	69	———	1	63	10,221.00	2,351.00	.78
6,000	112	1	798.00	184.00	.03	1	2,998.00	690.00	.12	133	———	1	123	11,377.00	2,617.00	.44
9,000	166	2	1,364.00	314.00	.04	1	3,214.00	739.00	.08	195	1	1	183	15,075.00	3,467.00	.39
12,000	220	2	1,580.00	363.00	.03	2	5,980.00	1,375.00	.12	262	1	1	246	16,288.00	3,747.00	.31
15,000	276	3	2,154.00	495.00	.04	2	6,204.00	1,427.00	.10	326	1	1	306	17,444.00	4,012.00	.27
30,000	542	4	3,568.00	821.00	.03	3	9,818.00	2,258.00	.08	645	2	2	615	34,905.00	8,028.00	.27
60,000	1,064	9	7,406.00	1,703.00	.03	7	22,106.00	5,084.00	.08	1,270	3	4	1,230	67,180.00	15,451.00	.26

[1] Includes cost of manual pallet transporter at $350 each; electric pallet transporter at $2,550 each; counterbalanced forklift truck at $9,000 each; racks at $15 per pallet storage position, and pallets at $4 each.
[2] Based on 23 percent of initial cost, which includes depreciation, interest, taxes, insurance, and maintenance.

TABLE 12.—*Equipment requirements and annual ownership and maintenance costs per ton for a fresh poultry wholesaler*

Annual volume	Pallets required	Manual pallet transporter method				Electric pallet transporter method				Counterbalanced forklift truck method						
		Transporters required	Total initial cost [1]	Annual cost [2]	Cost per ton	Transporters required	Total initial cost [1]	Annual cost [2]	Cost per ton	Pallets required	Electric pallet transporters required	Forklift trucks required	Racks required	Total initial cost [1]	Annual cost [2]	Cost per ton
Tons	*Number*	*Number*	*Dollars*	*Dollars*	*Dollars*	*Number*	*Dollars*	*Dollars*	*Dollars*	*Number*	*Number*	*Number*	*Number*	*Dollars*	*Dollars*	*Dollars*
1,000	11	1	394.00	91.00	0.09	1	2,594.00	597.00	0.60	14	----------	1	12	9,236.00	2,124.00	2.12
2,000	18	1	422.00	97.00	.05	1	2,622.00	603.00	.30	23	----------	1	21	9,407.00	2,163.00	1.08
3,000	27	1	458.00	106.00	.04	1	2,658.00	612.00	.20	33	----------	1	30	9,582.00	2,203.00	.73
6,000	53	1	562.00	129.00	.02	1	2,762.00	635.00	.11	62	----------	1	57	10,103.00	2,324.00	.39
9,000	77	2	1,012.00	232.00	.03	1	2,862.00	658.00	.07	94	1	1	87	13,231.00	3,043.00	.34
12,000	104	2	1,116.00	256.00	.02	2	5,516.00	1,278.00	.11	122	1	1	114	13,748.00	3,162.00	.26
15,000	130	2	1,220.00	281.00	.02	2	5,620.00	1,293.00	.09	154	1	1	144	14,326.00	3,295.00	.22
30,000	260	4	2,440.00	561.00	.02	3	8,690.00	1,999.00	.07	308	2	2	288	28,652.00	6,590.00	.22
60,000	510	8	4,840.00	1,113.00	.02	6	17,340.00	4,008.00	.06	606	3	4	576	54,714.00	12,583.00	.20

[1] Includes cost of manual pallet transporter at $350 each; electric pallet transporter at $2,550 each; counterbalanced forklift truck at $9,000 each; racks at $15 per pallet storage position, and pallets at $4 each.

[2] Based on 23 percent of initial cost, which includes depreciation, interest, taxes, insurance, and maintenance.

TABLE 13.—*Equipment requirements and annual ownership and maintenance costs per ton for dairy and egg wholesaler*

Annual volume	Pallets required	Manual pallet transporter method				Electric pallet transporter method				Counterbalanced forklift truck method						
		Transporters required	Total initial cost [1]	Annual cost [2]	Cost per ton	Transporters required	Total initial cost [1]	Annual cost [2]	Cost per ton	Pallets required	Electric pallet transporters required	Forklift trucks required	Racks required	Total initial cost [1]	Annual cost [2]	Cost per ton
Tons	*Number*	*Number*	*Dollars*	*Dollars*	*Dollars*	*Number*	*Dollars*	*Dollars*	*Dollars*	*Number*	*Number*	*Number*	*Number*	*Dollars*	*Dollars*	*Dollars*
1,000	17	1	418.00	96.00	0.10	1	2,618.00	602.00	0.60	20	----------	1	18	9,350.00	2,151.00	2.16
2,000	33	1	482.00	111.00	.06	1	2,682.00	617.00	.31	40	----------	1	36	9,700.00	2,231.00	1.12
3,000	49	1	546.00	126.00	.04	1	2,746.00	632.00	.21	57	----------	1	51	9,993.00	2,299.00	.77
6,000	94	2	1,076.00	248.00	.04	1	2,926.00	673.00	.11	110	----------	1	102	13,520.00	3,110.00	.52
9,000	140	2	1,260.00	290.00	.03	2	5,660.00	1,302.00	.15	165	1	1	153	14,505.00	3,336.00	.37
12,000	186	2	1,444.00	332.00	.03	2	5,844.00	1,344.00	.11	220	1	1	204	15,490.00	3,563.00	.30
15,000	233	3	1,982.00	456.00	.03	2	6,032.00	1,388.00	.09	275	1	1	255	16,475.00	3,789.00	.26
30,000	456	5	3,574.00	822.00	.03	3	9,474.00	2,179.00	.08	543	2	2	513	32,967.00	7,582.00	.26
60,000	891	9	6,174.00	1,544.00	.03	7	21,414.00	4,925.00	.09	1,063	3	4	1,023	63,247.00	14,547.00	.25

[1] Includes cost of manual pallet transporter at $350 each; electric pallet transporter at $2,550 each; counterbalanced forklift truck at $9,000 each; racks at $15 per pallet storage position, and pallets at $4 each.

[2] Based on 23 percent of initial cost, which includes depreciation, interest, taxes, insurance, and maintenance.

COST ANALYSIS

In this section of the report, cost per ton and annual costs are developed for each of the four types of wholesalers at the various volume levels studied. These costs include labor, equipment, and rent. Labor and equipment costs were discussed earlier in the report between pages 11 and 16. Rent is based on $7,200 per module, and module requirements are based on the most economical stacking arrangements shown in figures 5A, 5B, and 5C, and an average occupancy factor of 80 percent. When a wholesaler surpasses maximum storage capacity of the present facilities, it becomes necessary to acquire another module. However, this additional module may not be fully used at the new volume level, causing his rent per ton to be higher than his previous rent.

Complete-Line Produce Wholesaler

The product received is palletized either on the dock or in the vehicle, and then moved to a preselected location in storage. Outbound products are selected in the quantities ordered and moved on pallets to the loading vehicle where the selected pallet loads are dismantled for truck loading. The complete-line produce wholesaler would normally turn over his inventory every 3.2 working days, or 78 inventory turnovers annually.

The cost of product handling includes labor, equipment, and rent, each of which is separately identified in table 14 for the three systems studied. Also shown in table 14 is the total cost per ton handled and the total annual handling cost at each volume studied. At annual volumes between 1,000 and 4,000 tons, total costs are lower using pallet transporters and stacking one pallet high, compared with the forklift truck and stacking three tiers high. Above the 6,000-ton level, the forklift and rack method becomes the most economical system.

The savings for the forklift and rack method

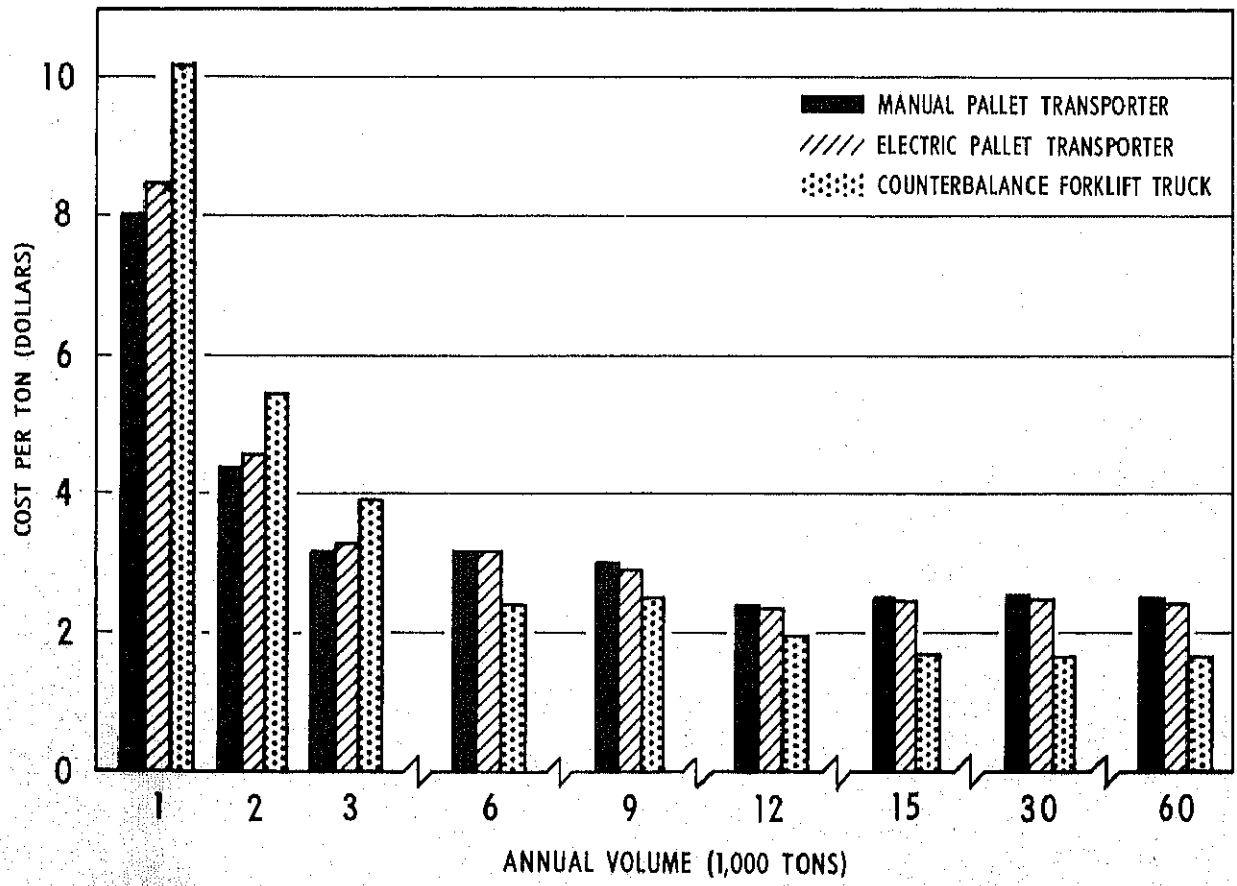

Figure 6.—Annual volume in 1,000 tons handling cost per ton, complete-line produce wholesaler.

over the lowest cost pallet-transporter method range from $4,680 at the 6,000-ton level to $43,800 at 60,000 tons. A graphic illustration of the data shown in table 14 is presented in figure 6.

Specialty Produce Wholesaler

The specialty produce wholesaler handles his product in a similar manner to that of the complete-line produce wholesaler, and has the same annual inventory turnover rate.

In table 15, the costs are shown for labor, equipment, and rent. As with the complete-line wholesaler, the total annual costs are lower when using the manual pallet transporter system compared with either the electric or forklift truck system at annual volume levels below 4,000 tons. Above the 6,000-ton level, the forklift truck and three-tier rack method becomes the most economical system.

The annual savings for the forklift and rack system over the electric pallet transporter system range from $4,920 at the 6,000-ton level to $42,000 at 60,000 tons. A graphic illustration of the data shown in table 15 is presented in figure 7.

Total annual cost is lower for a specialty produce wholesaler at levels of 6,000 tons and above, compared with the complete-line produce wholesaler. This difference is due to more products being shipped out as full-pallet loads, thereby reducing labor cost.

Fresh Poultry Wholesaler

The annual inventory turnovers for the fresh poultry wholesaler are more than twice those of the fresh fruit and vegetable wholesaler. At the same volume of business, the poultry wholesaler would require about half as much warehouse space as would the fresh fruit and vegetable wholesaler since his inventory would represent only about 1½ days' sales (166 annual turnovers), whereas the fresh fruit and vegetable wholesaler's inventory represents over 3 days' sales. Consequently, the poultry

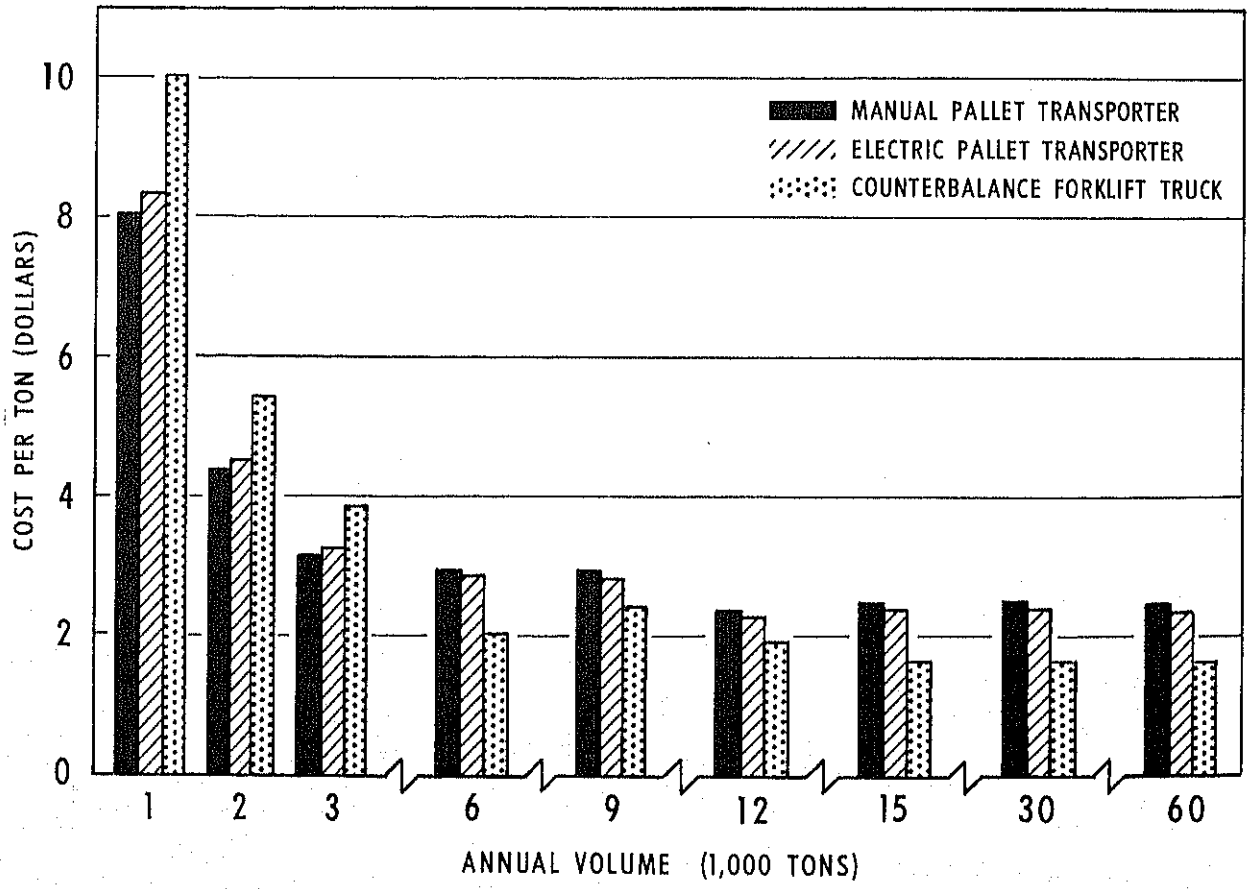

Figure 7.—Annual volume in 1,000 tons handling cost per ton, specialty produce wholesaler.

TABLE 14.—*Handling and space costs for complete-line produce wholesalers at selected volume levels*

Annual volume	Modules required [1]	Manual pallet transporter						Electric pallet transporter				Modules required [3]	Counterbalanced forklift					
		Rent per		Cost per ton			Cost per year	Cost per ton			Cost per year		Rent per		Cost per ton			Cost per year
		Year	Ton	Labor [2]	Equipment	Total cost		Labor [2]	Equipment	Total cost			Year	Ton	Labor	Equipment	Total cost	
Tons	*Number*	*Dollars*		*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Number*	*Dollars*		*Dollars*	*Dollars*	*Dollars*	*Dollars*
1,000	1	7,200	7.20	0.73	0.10	8.03	8,030	0.63	0.60	8.43	8,430	1	7,200	7.20	0.68	2.16	10.04	10,040
2,000	1	7,200	3.60	.71	.06	4.37	8,740	.62	.31	4.53	9,060	1	7,200	3.60	.67	1.13	5.40	10,800
3,000	1	7,200	2.40	.71	.04	3.15	9,450	.62	.21	3.23	9,690	1	7,200	2.40	.68	.78	3.86	11.580
6,000	2	14,400	2.40	.72	.03	3.15	18,900	.63	.12	3.15	18,900	1	7,200	1.20	.66	.44	2.37	14,220
9,000	3	21,600	2.40	.56	.04	3.00	27,000	.41	.08	2.89	26,010	2	14,400	1.60	.46	.39	2.45	22,050
12,000	3	21,600	1.80	.55	.03	2.38	28,560	.40	.12	2.32	27,840	2	14,400	1.20	.46	.31	1.97	23,640
15,000	4	28,800	1.92	.56	.04	2.50	37,500	.41	.10	2.43	36,450	2	14,400	.96	.44	.27	1.67	25,050
30,000	8	57,600	1.92	.57	.03	2.52	75,600	.43	.10	2.45	73,500	4	28,800	.96	.43	.27	1.66	49,800
60,000	15	108,000	1.80	.65	.03	2.48	148,800	.49	.10	2.39	143,400	8	57,600	.96	.44	.26	1.66	99,600

[1] Computed at 4,000 tons per module per year.
[2] The increase in labor cost at the 60,000-ton level is due to increased travel distance because of the large number of modules required.
[3] Computed at 8,100 tons per module per year.

TABLE 15.—*Handling and space costs for specialty produce wholesalers at selected volume levels*

Annual volume	Modules required [1]	Manual pallet transporter						Electric pallet transporter				Modules required [3]	Counterbalanced forklift					
		Rent per		Cost per ton			Cost per year	Cost per ton			Cost per year		Rent per		Cost per ton			Cost per year
		Year	Ton	Labor [2]	Equipment	Total cost		Labor [2]	Equipment	Total cost			Year	Ton	Labor [2]	Equipment	Total cost	
Tons	*Number*	*Dollars*		*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Number*	*Dollars*		*Dollars*	*Dollars*	*Dollars*	*Dollars*
1,000	1	7,200	7.20	0.73	0.10	8.03	8,030	0.63	0.60	8.43	8,430	1	7,200	7.20	0.68	2.16	10.04	10,040
2,000	1	7,200	3.60	.71	.06	4.37	8,740	.62	.31	4.53	9,060	1	7,200	3.60	.67	1.13	5.40	10,800
3,000	1	7,200	2.40	.71	.04	3.15	9,450	.62	.21	3.23	9,690	1	7,200	2.40	.68	.78	3.86	11,580
6,000	2	14,400	2.40	.51	.03	2.94	17,640	.34	.12	2.86	17,160	1	7,200	1.20	.40	.44	2.04	12,240
9,000	3	21,600	2.40	.53	.04	2.97	26,730	.34	.08	2.82	25,380	2	14,400	1.60	.40	.39	2.39	21,510
12,000	3	21,600	1.80	.50	.03	2.33	27,960	.34	.12	2.26	27,120	2	14,400	1.20	.39	.31	1.90	22,800
15,000	4	28,800	1.92	.50	.04	2.46	36,900	.34	.10	2.36	35,400	2	14,400	.96	.38	.27	1.61	24,150
30,000	8	57,600	1.92	.53	.03	2.48	74,400	.37	.08	2.37	71,100	4	28,800	.96	.38	.27	1.61	48,300
60,000	15	108,000	1.80	.60	.03	2.43	145,800	.43	.08	2.31	138,600	8	57,600	.96	.39	.26	1.61	96,600

[1] Computed at 4,000 tons per module per year.
[2] The increase in labor cost at the 60,000-ton level is due to increased travel distance because of the large number of modules required.
[3] Computed at 8,100 tons per module per year.

wholesaler could operate from a typical module with the one-high pallet arrangement at more than twice the annual volume of the fresh fruit and vegetable firm.

Shown in table 16 is product-handling cost at various annual tonnages, including labor, equipment, and rent identified for each type of handling system. A graphic illustration of the data in table 16 is presented in figure 8. Also shown in table 16 is the total cost per ton and the total cost per year for each volume level studied. At annual volumes between 1,000 and 8,500 tons, total costs are lower using pallet transporters and stacking one pallet high, compared with the forklift truck and stacking three tiers high. Above the 9,000-ton level, the forklift and rack method becomes the most economical system. The savings for the forklift and rack system range from $4,310 at the 9,000-ton level, to $11,400 at 60,000 tons, compared with the electric pallet transporter system.

Dairy and Egg Wholesaler

A dairy and egg wholesaler with an average turnover of 94 times a year can handle up to 4,800 tons annually in one module using pallet transporters and one-high pallet arrangement. He can handle up to 8,000 tons annually using forklift trucks and pallet racks.

Labor, equipment, and rent for the three handling systems are shown in table 17. At annual volumes between 1,000 to 4,800 tons, total costs are lower using pallet transporters and stacking one pallet high, compared to the forklift truck and stacking three tiers high. Above the 6,000-ton level, the forklift and rack method becomes the most economical system.

The annual savings for the forklift and rack system over the electric pallet transporter range from $4,500 at the 6,000-ton level to $35,400 at 60,000 tons. A graphic illustration of the data shown in table 17 is presented in figure 9.

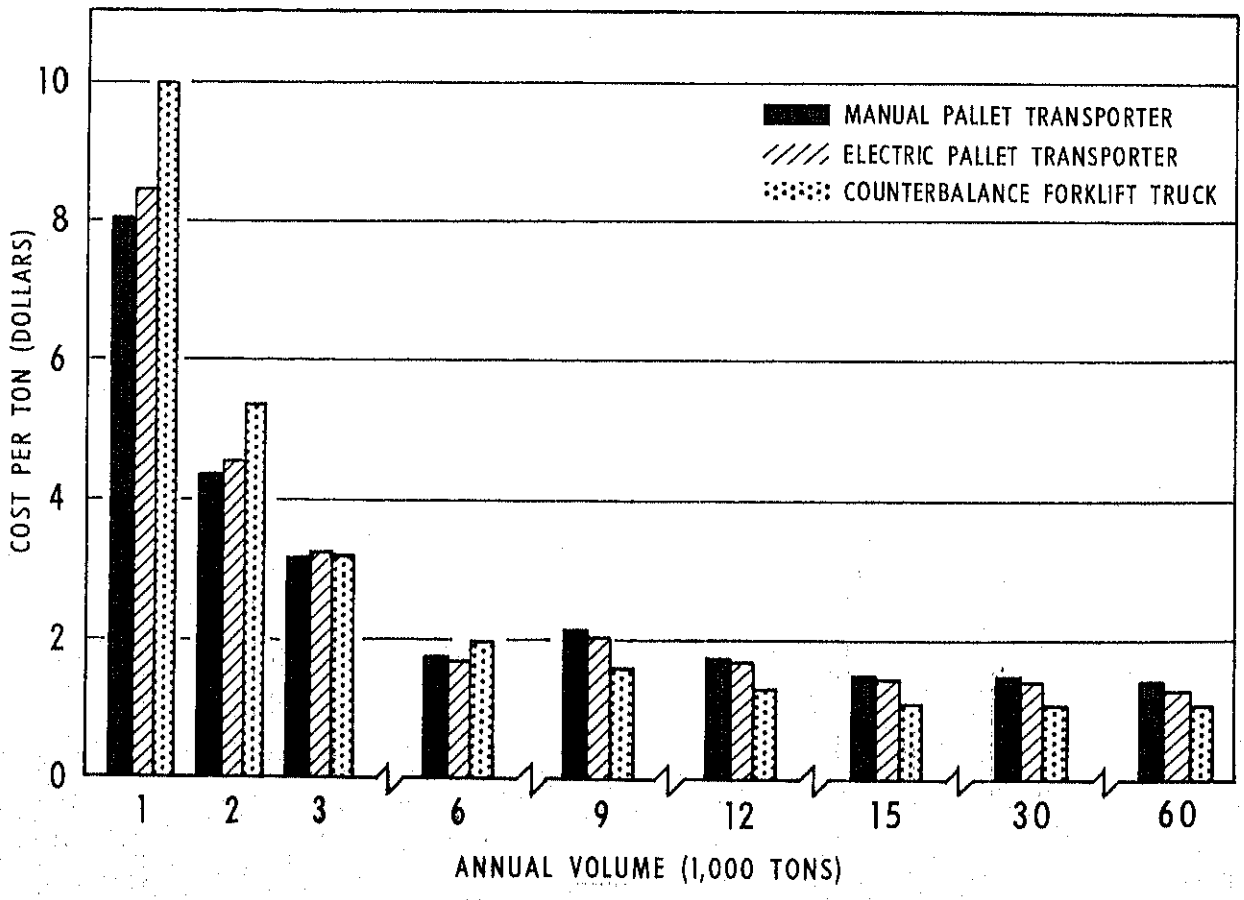

Figure 8.—Annual volume in 1,000 tons handling cost per ton, fresh poultry wholesaler.

TABLE 16.—*Handling and space costs for fresh poultry wholesalers at selected volume levels*

Annual volume	Modules required [1]	Rent per		Manual pallet transporter				Electric pallet transporter				Modules required [3]	Rent per		Counterbalanced forklift			
				Cost per ton			Cost per year	Cost per ton			Cost per year				Cost per ton			Cost per year
		Year	Ton	Labor [2]	Equipment	Total cost		Labor [2]	Equipment	Total cost			Year	Ton	Labor [2]	Equipment	Total cost	
Tons	*Number*	*Dollars*		*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Number*	*Dollars*		*Dollars*	*Dollars*	*Dollars*	*Dollars*
1,000	1	7,200	7.20	0.73	0.09	8.02	8,020	0.63	0.60	8.43	8,430	1	7,200	7.20	0.68	2.12	10.00	10,000
2,000	1	7,200	3.60	.71	.05	4.36	8,720	.62	.30	4.52	9,040	1	7,200	3.60	.67	1.08	5.35	10,700
3,000	1	7,200	2.40	.71	.04	3.15	9,450	.62	.20	3.22	9,660	1	7,200	2.40	.68	.73	3.18	9,540
6,000	1	7,200	1.20	.50	.02	1.72	10,320	.33	.11	1.64	9,840	1	7,200	1.20	.40	.39	1.99	11,940
9,000	2	14,400	1.60	.50	.03	2.13	19,170	.34	.07	2.01	18,090	1	7,200	.80	.39	.34	1.53	13,770
12,000	2	14,400	1.20	.49	.02	1.71	20,520	.33	.11	1.64	19,680	1	7,200	.60	.38	.26	1.24	14,880
15,000	2	14,400	.96	.48	.02	1.46	21,900	.33	.09	1.38	20,700	1	7,200	.48	.37	.22	1.07	16,050
30,000	4	28,800	.96	.48	.02	1.46	43,800	.32	.07	1.35	40,500	2	14,400	.48	.34	.22	1.04	31,200
60,000	7	50,400	.84	.50	.02	1.36	81,600	.33	.06	1.23	73,800	4	28,800	.48	.36	.20	1.04	62,400

[1] Computed at 8,500 tons per module per year.
[2] The increase in labor cost at the 60,000-ton level is due to increased travel distance because of the large number of modules required.
[3] Computed at 17,200 tons per module per year.

TABLE 17.—*Handling and space costs for dairy and egg wholesalers at selected volume levels*

Annual volume	Modules required [1]	Rent per		Manual pallet transporter				Electric pallet transporter				Modules required [3]	Rent per		Counterbalanced forklift			
				Cost per ton			Cost per year	Cost per ton			Cost per year				Cost per ton			Cost per year
		Year	Ton	Labor [2]	Equipment	Total cost		Labor [2]	Equipment	Total cost			Year	Ton	Labor	Equipment	Total cost	
Tons	*Number*	*Dollars*		*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Number*	*Dollars*		*Dollars*	*Dollars*	*Dollars*	*Dollars*
1,000	1	7,200	7.20	0.73	0.10	8.03	8,030	0.63	0.60	8.43	8,430	1	7,200	7.20	0.68	2.16	10.04	10,040
2,000	1	7,200	3.60	.71	.06	4.37	8,740	.62	.31	4.53	9,060	1	7,200	3.60	.67	1.12	5.39	10,780
3,000	1	7,200	2.40	.71	.04	3.15	9,450	.62	.21	3.23	9,690	1	7,200	2.40	.68	.77	3.85	11,550
6,000	2	14,400	2.40	.72	.04	3.16	18,960	.63	.11	3.14	18,840	1	7,200	1.20	.67	.52	2.39	14,340
9,000	2	14,400	1.60	.73	.03	2.36	21,240	.63	.15	2.38	21,420	1	7,200	.80	.67	.37	1.84	16,560
12,000	3	21,600	1.80	.62	.03	2.45	29,400	.49	.11	2.40	28,800	2	14,400	1.20	.54	.30	2.04	24,480
15,000	3	21,600	1.44	.54	.03	2.01	30,150	.38	.09	1.91	28,650	2	14,400	.96	.43	.26	1.65	24,750
30,000	6	43,200	1.44	.55	.03	2.02	60,500	.39	.08	1.91	57,300	3	21,600	.72	.42	.26	1.40	42,000
60,000	12	86,400	1.44	.61	.03	2.08	124,800	.45	.09	1.98	118,800	6	43,200	.72	.42	.25	1.39	83,400

[1] Computed at 4,800 tons per module per year.
[2] The increase in labor cost at the 60,000-ton level is due to increased travel distance because of the large number of modules required.
[3] Computed at 8,100 tons per module per year.